CLAIMS

What is claimed is:

1. A method for a distributed medium access protocol that schedules transmission of different types of packets on a channel based on a service quality specification for each type of packet, comprising the steps of:

determining at a plurality of nodes in the access network, an urgency class of pending packets according to a scheduling algorithm;

transmitting pending packets in a given urgency class before transmitting packets of a lower urgency class;

remembering the number of transmission attempts by a node for the last transmission of same node;

estimating from said number of transmission attempts the current congestion experienced; and

adjusting a backoff counter to current congestion levels to provide a dispersion of packet traffic bursts.

2. The method for a distributed medium access protocol of claim 1, which further comprises:

broadcasting with each transmission the number of transmission attempts by a node;

estimating from said number of transmission attempts received from other nodes the current congestion experienced; and

adjusting a backoff counter to current congestion levels to provide a dispersion of packet traffic bursts.

3. The method for a distributed medium access protocol of claim 1, which further comprises:

broadcasting with each transmission the number of transmission attempts by a node;

estimating from said number of transmission attempts received from other nodes the current congestion experienced; and

adjusting a backoff counter to current congestion levels to provide a dispersion of packet traffic bursts.

4. The method for a distributed medium access protocol of claim 1, which further comprises:

remembering the number of transmission attempts for packets of every urgency class by a node for the last transmission in that class of same node;

estimating from said number of transmission attempts the current congestion experienced by the urgency class of a pending packet; and

adjusting a backoff counter for the pending packet to current congestion levels to provide a dispersion of packet traffic bursts.

5. The method for a distributed medium access protocol of claim 1, which further comprises:

broadcasting with each transmission the number of transmission attempts by a node and the assigned urgency class;

estimating from said number of transmission attempts received from other nodes the current congestion experienced by the urgency class of the pending packet; and

adjusting a backoff counter of the pending packet to current congestion levels to provide a dispersion of packet traffic bursts.

6. The method for a distributed medium access protocol of claim 1, which further comprises:

broadcasting with each transmission the number of transmission attempts by a node and the assigned urgency class;

estimating from said number of transmission attempts received from other nodes the current congestion experienced by the urgency class of the pending packet; and

adjusting a backoff counter of the pending packet to current congestion levels to provide a dispersion of packet traffic bursts.

7. The method for a distributed medium access protocol of claim 1, which further comprises:

initializing backoff counters with a relatively longer value, and then decreasing the value upon transmission failure and retrial.

8. The method for a distributed medium access protocol of claim 1, which further comprises:

remembering the number of transmission attempts by a node for the last transmission of same node;

estimating from said number of transmission attempts the current congestion experienced; and

adjusting a persistence probability to current congestion levels to provide a dispersion of packet traffic bursts.

9. The method for a distributed medium access protocol of claim 1, which further comprises:

broadcasting with each transmission the number of transmission attempts by a node;

estimating from said number of transmission attempts received from other nodes the current congestion experienced; and

adjusting a persistence probability to current congestion levels to provide a dispersion of packet traffic bursts.

10. The method for a distributed medium access protocol of claim 1, which further comprises:

broadcasting with each transmission the number of transmission attempts by a node;

estimating from said number of transmission attempts received from other nodes the current congestion experienced; and

adjusting a persistence probability to current congestion levels to provide a dispersion of packet traffic bursts.

11. The method for a distributed medium access protocol of claim 1, which further comprises:

remembering the number of transmission attempts for packets of every urgency class by a node for the last transmission in that class of same node;

estimating from said number of transmission attempts the current congestion experienced by the urgency class of a pending packet; and

adjusting a persistence probability for the pending packet to current congestion levels to provide a dispersion of packet traffic bursts.

12. The method for a distributed medium access protocol of claim 1, which further comprises:

broadcasting with each transmission the number of transmission attempts by a node and the assigned urgency class;

estimating from said number of transmission attempts received from other nodes the current congestion experienced by the urgency class of the pending packet; and

adjusting a persistence probability of the pending packet to current congestion levels to provide a dispersion of packet traffic bursts.

13. The method for a distributed medium access protocol of claim 1, which further comprises:

broadcasting with each transmission the number of transmission attempts by a node and the assigned urgency class;

estimating from said number of transmission attempts received from other nodes the current congestion experienced by the urgency class of the pending packet; and

adjusting a persistence probability of the pending packet to current congestion levels to provide a dispersion of packet traffic bursts.

14. The method for a distributed medium access protocol of claim 1, which further comprises:

initializing the persistence probability with a relatively lower value, and then increasing the value upon transmission failure and retrial.

15. The method for a distributed medium access protocol of claim 1, which further comprises:

establishing criteria for cancellation of transmission of a packet associated with packet delay.

16. The method for a distributed medium access protocol of claim 1, which further comprises:

applying backoff prior to attempting any transmission.

17. The method for a distributed medium access protocol of claim 1, which further comprises:

checking for permission to transmit by using a specified persistence probability prior to attempting any transmission.

18. The method for a distributed medium access protocol of claim 1, which further comprises:

applying the method to wireless networks.

19. The method for a distributed medium access protocol of claim 1, which further comprises:

applying the method to cellular packet networks.

20. The method for a distributed medium access protocol of claim 1, which further comprises:

applying the method to multi-channel air interface systems selected from the group consisting of FDMA, TDMA, OFDM, and CDMA.

21. The method for a distributed medium access protocol of claim 1, which further comprises:

applying the method to wireline transmission media.

22. The method for a distributed medium access protocol of claim 1, which further comprises:

applying the method to optical transmission media.

23. A method for a distributed medium access protocol that schedules transmission of different types of packets on a channel based on a service quality specification for each type of packet, comprising the steps of:

determining at a plurality of nodes in the access network, an urgency class of pending packets according to a scheduling algorithm;

using class-differentiated arbitration times, as idle time intervals required before transmission is attempted; and

assigning shorter arbitration times to higher urgency classes.

24. A method for a distributed medium access protocol that schedules transmission of different types of packets on a channel based on a service quality specification for each type of packet, comprising the steps of:

determining at a plurality of nodes in the access network, an urgency class of pending packets according to a scheduling algorithm;

using class-differentiated arbitration times, as idle time intervals required before a backoff counter is decreased; and

assigning shorter arbitration times to higher urgency classes.

25. The method for a distributed medium access protocol of claim 23, which further comprises:

adjusting backoff probability density functions in real time based on congestion estimates derived from a number of re-transmissions attempted by a node.

26. The method for a distributed medium access protocol of claim 24, which further comprises:

adjusting backoff probability density functions in real time based on congestion estimates derived from a number of re-transmissions attempted by a node.

27. The method for a distributed medium access protocol of claim 25, which further comprises:

adjusting backoff probability density functions in real time based on congestion estimates derived from a number of re-transmissions attempted by each of its neighbor nodes.

28. The method for a distributed medium access protocol of claim 26, which further comprises:

adjusting backoff probability density functions in real time, based on congestion estimates derived from a number of re-transmissions attempted by each of its neighbor nodes.

29. The method for a distributed medium access protocol of claim 23, which further comprises:

adjusting backoff probability density functions in real time based on class-specific congestion estimates derived from a number of re-transmissions attempted by a node.

30. The method for a distributed medium access protocol of claim 24, which further comprises:

adjusting backoff probability density functions in real time based on class-specific congestion estimates derived from a number of re-transmissions attempted by a node.

31. The method for a distributed medium access protocol of claim 25, which further comprises:

adjusting backoff probability density functions in real time based on class-specific congestion estimates derived from a number of re-transmissions attempted by each of its neighbor nodes.

32. The method for a distributed medium access protocol of claim 26, which further comprises:

adjusting backoff probability density functions in real time based on class-specific congestion estimates derived from a number of re-transmissions attempted by each of its neighbor nodes.

33. The method for a distributed medium access protocol of claim 23, which further comprises:

adjusting backoff probability density functions in real time based on congestion estimates derived from a number of re-transmissions attempted by a node.

34. The method for a distributed medium access protocol of claim 23, which further comprises:

adjusting backoff probability density functions in real time at a node based on congestion estimates derived from the time spent by packets waiting for transmission.

35. The method for a distributed medium access protocol of claim 24, which further comprises:

adjusting backoff probability density functions in real time at a node based on congestion estimates derived from the time spent by packets waiting for transmission.

36. The method for a distributed medium access protocol of claim 34, which further comprises:

adjusting backoff probability density functions in real time at a node based on congestion estimates derived from the time spent by packets waiting for transmission at each of its neighbor nodes.

37. The method for a distributed medium access protocol of claim 35, which further comprises:

adjusting backoff probability density functions in real time at a node based on congestion estimates derived from the time spent by packets waiting for transmission at each of its neighbor nodes.

38. The method for a distributed medium access protocol of claim 23, which further comprises:

adjusting backoff probability density functions in real time at a node based on class-specific congestion estimates derived from the time spent by packets of different classes waiting for transmission.

39. The method for a distributed medium access protocol of claim 24, which further comprises:

adjusting backoff probability density functions in real time at a node based on class-specific congestion estimates derived from the time spent by packets of different classes waiting for transmission.

40. The method for a distributed medium access protocol of claim 38, which further comprises:

adjusting backoff probability density functions in real time at a node based on class-specific congestion estimates derived from the time spent by packets of different classes waiting for transmission at each of its neighbor nodes.

41. The method for a distributed medium access protocol of claim 39, which further comprises:

adjusting backoff probability density functions in real time at a node based on class-specific congestion estimates derived from the time spent by packets of different classes waiting for transmission at each of its neighbor nodes.

42. A method for a distributed medium access protocol, comprising:

scheduling transmission of different types of packets on a shared channel; and

including information in the transmitted packets concerning the number of transmission attempts.

43. A method for a distributed medium access protocol, comprising:

scheduling transmission of different types of packets on a shared channel; and

including information in the transmitted packets concerning the time spent by the packet waiting transmission.

44. The method for a distributed medium access protocol of claim 42, which further comprises:

further differentiating packets into different urgency classes based on different backoff distributions for different packets that are assigned the same urgency arbitration time.

45. The method for a distributed medium access protocol of claim 43, which further comprises:

further differentiating packets into different urgency classes based on different backoff distributions for different packets that are assigned the same urgency arbitration time.

46. The method for a distributed medium access protocol of claim 23, which further comprises:

further differentiating packets into urgency classes based on probability density functions of backoff counters whose superposition yields a uniform composite density function, thus achieving efficient dispersion of contending stations' backoff time.

47. The method for a distributed medium access protocol of claim 24, which further comprises:

further differentiating packets into urgency classes based on probability density functions of backoff counters whose superposition yields a uniform composite density function, thus achieving efficient dispersion of contending stations' backoff time.

48. The method for a distributed medium access protocol of claim 23, which further comprises:

further differentiating packets into urgency classes based on different permission probabilities, by which permission is granted for transmission, for different packets that are assigned the same urgency arbitration time.

49. The method for a distributed medium access protocol of claim 24, which further comprises:

further differentiating packets into urgency classes based on different permission probabilities, by which permission is granted for transmission, for different packets that are assigned the same urgency arbitration time.

50. A method for a distributed medium access protocol that schedules transmission of different types of packets on a channel based on a service quality specification for each type of packet, comprising the steps of:

determining at a plurality of nodes in the access network, an urgency class of pending packets according to a scheduling algorithm; and

using class-differentiated retrial functions that are used to update parameters of backoff distribution used following transmission failure and subsequent transmission retrial.

51. A method for a distributed medium access protocol that schedules transmission of different types of packets on a channel based on a service quality specification for each type of packet, comprising:

determining in a first wireless station a first urgency class of data having a low QoS requirement;

assigning a first class-differentiated urgency arbitration time to said data having a lower QoS requirement;

determining in a second wireless station a second urgency class of data having a high QoS requirement;

assigning a second class-differentiated urgency arbitration time shorter than said first time, to said data having a higher QoS requirement;

transmitting from said second wireless station pending packets in said second urgency class before transmitting from said first wireless station pending packets in said first urgency class; and

said urgency classes each having a correspondence urgency arbitration time that must expire before starting a random backoff interval for packets assigned to that urgency class.

52. The method of claim 51, wherein:

said random backoff interval is calculated based on a contention window range which has an initial lower value and an initial upper value, which are functions of the urgency class.

53. The method of claim 51, wherein:

said random backoff interval is selected randomly from a statistical distribution, whose mean and variance are set adaptively in response to an observed traffic intensity.

54. The method of claim 51, which further comprises:

differentiating between different urgency class transmissions with class-specific parameters of the probability distribution used to generate random backoff times and class-specific backoff retry adjustment functions.

55. The method of claim 51, which further comprises:

differentiating between different urgency class transmissions with a persistence factor, pf_i, that is different for each class i, which is used to multiply a backoff window from which backoff counters will be drawn randomly upon transmission retrial.

56. The method of claim 51, which further comprises:

differentiating between different urgency class transmissions with a new backoff range determined by traffic congestion estimates.

57. The method of claim 56, wherein:

said congestion estimates are derived from data that include feedback on success or failure of a transmission attempt.

58. The method of claim 56, wherein:

said congestion estimates are derived from data that include feedback on a number of re-transmissions attempted by a node.

59. The method of claim 56, wherein:

said congestion estimates are derived from data that include feedback on a number of re-transmissions attempted by neighbor nodes.

60. The method of claim 56, wherein:

said congestion estimates are derived from data that include feedback on age of retrials of transmissions attempted.

61. The method of claim 56, wherein:

said congestion estimates are derived from data that include feedback on attempted transmissions provided in reservation messages.

62. The method of claim 56, wherein:

said congestion estimates are derived from data that include feedback on attempted transmissions provided in request to send and clear to send messages.

63. The method of claim 56, wherein:

said congestion estimates are derived from data that include feedback on attempted transmissions provided in headers of transmitted packets.

64. A method for a medium access protocol that schedules transmission of packets from a plurality of nodes on a channel, comprising the steps of:

employing a backoff countdown procedure for channel access;

monitoring traffic intensity changes continuously and providing feedback to the MAC sublayer of contending nodes;

adjusting a backoff counter of each of a plurality of contending nodes to current congestion levels in time intervals shorter than required for the completion of a transmission attempt; and

adjusting such backoff counter in a way that enables older packets to be transmitted before newer ones with high probability, thus minimizing the latency jitter.

65. The method for a medium access protocol of claim 64, which further comprises:

adjusting such backoff counter in a way that their relative ordering is preserved.

66. The method for a medium access protocol of claim 65, which further comprises:

determining the magnitude of an adjustment factor that is larger for greater congestion;

adjusting a backoff counter of the pending packet to increased congestion levels by increasing the backoff counter values associated with each of a plurality of contending nodes by scaling up such counter through the addition of an increment that is proportional to the current counter value and increases with the scaling factor; and

adding a random integer number drawn from a range bounded by 0 and said adjustment factor.

67. The method for a medium access protocol of claim 65, which further comprises:

determining the magnitude of an adjustment factor that is larger for lower congestion; and

adjusting a backoff counter of the pending packet to decreased congestion levels by decreasing the backoff counter values associated with each of a plurality of contending nodes by scaling down in inverse proportion to said scaling factor.

68. The method for a medium access protocol of claim 66, which further comprises:

selecting the magnitude of the adjustment factor at a given congestion level so that it is smaller for higher priority nodes, thus allowing higher priority packets to be transmitted earlier.

69. The method for a medium access protocol of claim 67, which further comprises:

selecting the magnitude of the adjustment factor at a given congestion level so that it is greater for higher priority nodes, thus allowing higher priority packets to be transmitted earlier.

70. The method for a medium access protocol of claim 66, which further comprises:

selecting the magnitude of the adjustment factor at a given congestion level so that it is smaller for nodes subscribing to a higher premium service, thus enabling higher premium packets to be transmitted earlier.

71. The method for a medium access protocol of claim 67, which further comprises:

selecting the magnitude of the adjustment factor at a given congestion level so that it is greater for nodes subscribing to a higher premium service, thus allowing higher premium packets to be transmitted earlier.

72. A method for a medium access protocol that schedules transmission of packets from a plurality of nodes on a channel, comprising the steps of:

employing a backoff countdown procedure for random channel access;

monitoring the traffic continuously and providing feedback to the MAC sublayer of contending nodes; and

adjusting the parameters (e.g. offset and window size, or range) of a random distribution from which the backoff counter is drawn upon initiation of a transmission attempt for each of a plurality of contending nodes to reflect current congestion levels.

73. The method for a medium access protocol of claim 72, which further comprises:

adjusting a backoff counter of each of a plurality of backlogged nodes to reflect current contention levels in time intervals shorter than required for the completion of a transmission attempt; and

adjusting such backoff counters in a way that enables older packets to be transmitted before newer ones with high probability, thus minimizing the latency jitter.

74. The method for a medium access protocol of claim 72, which further comprises:

obtaining traffic intensity measurements continuously and providing feedback to the MAC sublayer of contending nodes.

75. The method for a medium access protocol of claim 72, which further comprises:

obtaining feedback on the status (e.g. success or failure) of transmissions and channel idle time continuously and providing such feedback to the MAC sublayer of contending nodes.

76. The method for a medium access protocol of claim 72, which further comprises:

employing feedback information to estimate the expected number of backlogged nodes; and

using such estimate for the purpose of backoff-related adjustments.

77. The method for a medium access protocol of claim 72, which further comprises:

employing feedback information to estimate the expected number of backlogged nodes; and

using such estimate for the purpose of backoff-related adjustments.

78. The method for a medium access protocol of claim 72, which further comprises:

employing a wireless channel; and

performing the monitoring of the channel at the access port.

79. The method for a medium access protocol of claim 72, which further comprises:

employing a wireless channel; and

performing the monitoring of the channel at each of the contending nodes.

80. The method for a medium access protocol of claim 72, which further comprises:

determining system-wide adjustments at the access port; and

supplying such adjustments to all nodes.

81. The method for a medium access protocol of claim 72, which further comprises:

determining the magnitude of an adjustment factor R that is larger for greater contention levels; and

adjusting the backoff distribution parameters to increased contention levels by increasing parameter values associated with each of a plurality of contending nodes by scaling up such parameters through the addition of an increment that is proportional to the current counter value and increases with the scaling factor (1+R).

82. The method for a medium access protocol of claim 72, which further comprises:

determining the magnitude of an adjustment factor D that is larger for lower contention levels; and

adjusting the backoff distribution parameters to decreased contention levels by decreasing such parameters associated with each of a plurality of contending nodes by scaling down in inverse proportion to the scaling factor (1+D).

83. The method for a medium access protocol of claim 73, which further comprises: adjusting such backoff counter in a way that their relative ordering is preserved.

84. The method for a medium access protocol of claim 83, which further comprises: determining the magnitude of an integer adjustment factor R that is larger for greater contention levels;

adjusting a backoff counter of the pending packet to increased contention levels by increasing the backoff counter values associated with each of a plurality of backlogged nodes by scaling up such counter through the addition of an increment that is proportional to the current counter value and increases with the scaling factor (1+R); and

adding a random integer number drawn from a range bounded by 0 and said adjustment factor R.

85. The method for a medium access protocol of 83, which further comprises: determining the magnitude of a fractional adjustment factor R that is larger for greater contention levels;

adjusting a backoff counter of the pending packet to increased contention levels by increasing the backoff counter values associated with each of a plurality of backlogged nodes by

scaling up such counter through the multiplication of the current counter value by a term that increases with the scaling factor (1+R); and

assigning, through statistical means, an integer value to such counter with expected value equal to said multiplication product.

86. The method for a medium access protocol of claim 83, which further comprises:

determining the magnitude of an integer adjustment factor D that is larger for lower contention levels; and

adjusting a backoff counter of the pending packet to decreased contention levels by decreasing the backoff counter values associated with each of a plurality of backlogged nodes by scaling down in inverse proportion to the scaling factor (1+D).

87. The method for a medium access protocol of claim 83, which further comprises:

determining the magnitude of a fractional adjustment factor D that is larger for lower congestion;

adjusting a backoff counter of the pending packet to increased contention levels by increasing the backoff counter values associated with each of a plurality of backlogged nodes by scaling down such counter through the multiplication of the current counter value by a term that increases in inverse proportion to the scaling factor (1+D); and

assigning, through statistical means, an integer value to such counter with expected value equal to said multiplication product.

88. The method for a medium access protocol of claim 81, which further comprises:

while monitoring the contention levels, performing a scaling adjustment when its magnitude exceeds a specified step size, thus maintaining responsive adjustment with an efficient computation load.

89. The method for a medium access protocol of claim 82, which further comprises:

while monitoring the contention levels, performing a scaling adjustment when its magnitude exceeds a specified step size, thus maintaining responsive adjustment with an efficient computation load.

90. The method for a medium access protocol of claim 84, which further comprises:

while monitoring the contention levels, performing a scaling adjustment when its magnitude exceeds a specified step size, thus maintaining responsive adjustment with an efficient computation load.

91. The method for a medium access protocol of claim 85, which further comprises:

while monitoring the contention levels, performing a scaling adjustment when its magnitude exceeds a specified step size, thus maintaining responsive adjustment with an efficient computation load.

92. The method for a medium access protocol of claim 81, which further comprises:

selecting the magnitude of the adjustment factor at a given contention level so that it is smaller for higher priority nodes, thus allowing higher priority packets to be transmitted earlier.

93. The method for a medium access protocol of claim 84, which further comprises: selecting the magnitude of the adjustment factor at a given contention level so that it is smaller for higher priority nodes, thus allowing higher priority packets to be transmitted earlier.

94. The method for a medium access protocol of claim 85, which further comprises: selecting the magnitude of the adjustment factor at a given contention level so that it is smaller for higher priority nodes, thus allowing higher priority packets to be transmitted earlier.

95. The method for a medium access protocol of claim 82, which further comprises: selecting the magnitude of the adjustment factor at a given contention level so that it is greater for higher priority nodes, thus allowing higher priority packets to be transmitted earlier.

96. The method for a medium access protocol of claim 86, which further comprises: selecting the magnitude of the adjustment factor at a given contention level so that it is greater for higher priority nodes, thus allowing higher priority packets to be transmitted earlier.

97. The method for a medium access protocol of claim 87, which further comprises: selecting the magnitude of the adjustment factor at a given contention level so that it is greater for higher priority nodes, thus allowing higher priority packets to be transmitted earlier.